SASKATOON HEALTH REGION

SUCTIONING ARTIFICIAL AIRWAYS: PEDIATRIC/NEONATE (Tracheostomies & Endotracheal Tubes)

RN and LPN/SA LEARNING PACKAGE

- **Suctioning: Ventilated (Conventional and High Frequency) Patients: Pediatric/Neonate**

RN – SPECIAL NURSING PROCEDURE

&

- **Suctioning: Non-ventilated and Long-term ventilated Patients Via a Tracheostomy: Pediatric/Neonate**

RN – SPECIAL NURSING PROCEDURE; LPN AND SENIOR ASSISTANT – ADDED SKILL

Registered Nurse/LPN/SA identified by their Manager will be certified to perform suctioning via endotracheal and/or tracheostomy tubes in accordance with the policy of the clinical unit.

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1.0 GENERAL INFORMATION

1.1 Criteria for Certification

- Completion of Unit Specific Orientation
- Review of the learning package and completion of the review questions.
- Satisfactory demonstration of the clinical skills to a Clinical Nurse Educator in a patient and/or lab simulation setting.

1.2 Criteria for Recertification

- Recertification is required annually for LPNs/SA who are not performing the skill regularly.
- Recertification may be done upon the request of the Manager of Nursing, Clinical Nurse Educator or the individual RN or LPN/SA.

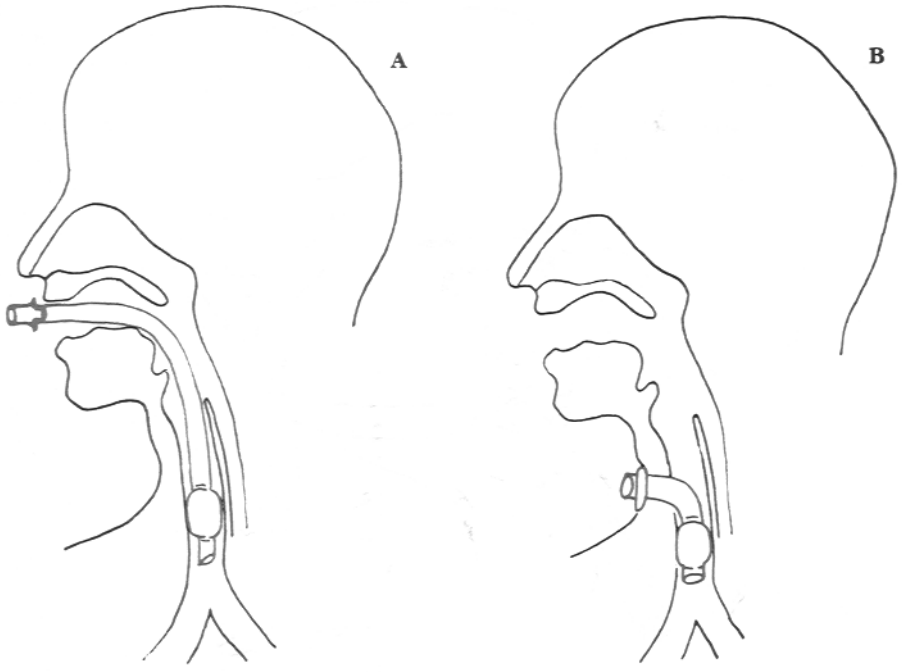
2.0 THEORY

2.1 Artificial Airways

Artificial Airways discussed in this package are endotracheal tubes and tracheostomy tubes.

The indications for an artificial airway are:

- Bypass an airway obstruction: tumors, foreign body, larynx or tracheal injury or congenital malformations
- Provide protection from aspiration in patients having difficulty protecting their airway (diminished cough, gag swallow) due to CNS impairments (brain injury, progressive neurological or muscle disorder ex. muscular dystrophy) Note: Patients with Glasgow coma scale <8 require airway management.
- Provide mechanical ventilation to patient with severe respiratory disease , shock or multi-system trauma or sepsis
- Remove secretions from tracheobronchial tree
- Tracheostomy is usually done for patients requiring prolonged mechanical ventilation (months to years) or for same indications as an ETT (bypass obstruction, protect from aspiration and remove secretions).



A Position Of Endotracheal Tube B Position Of Tracheostomy Tube

Source: adapted from Phipps et al (1995) Medical Surgical Nursing 5th Edition, p.1021. Mosby-Year Book, Inc.: St. Louis, Missouri.

2.1.1 Endotracheal Tubes (ETT's)

An endotracheal tube is a tube inserted into the trachea to ensure patency of the upper airway, allow for mechanical ventilation and provide pulmonary hygiene. It can be inserted through the mouth, (orotracheal tube), or through the nose, (nasotracheal tube).
Adults and children over 1 year may utilize "cuffed" tubes to help seal the airway, and aid in mechanical ventilation. The cuff is a balloon-like device that circles the lower end of the tube. It is attached to a very narrow tube which connects to the pilot balloon to a valve allowing access to cuff for filling with air (or saline for aeromedical transport). Uncuffed or Straight ETT's are usually used in children under 8 years of age as their airways are narrower at the cricoid cartilage which provides a natural seal around the ETT.

The size of the tube and depth of tube insertion depends on the size of the patient's airway. The diameter is measured in millimeters (mm) and used to describe the endotracheal tube. Most ETT's are available cuffed or uncuffed. Formula's for ETT size:

Uncuffed: $\frac{\text{patient age (in years)}}{4} + 4$ Cuffed: $\frac{\text{Patient age} + 3}{3}$

ETT's require insertion by a person specially trained in this skill (such as an anesthesiologist, respiratory therapist, etc.) and children usually require a regime of medications (atropine, sedatives, analgesics and paralytics) to facilitate insertion unless in cardiopulmonary arrest. ETT's are designed for short term use (hours to few weeks) as are uncomfortable to the awake child, can traumatize oral and nasal mucos, impair oral feeding and vocalizations.

2.1.2 Traecheostomy Tubes

Tracheotomy is an incision made into the trachea. A Tracheostomy is the opening or stoma created by a tracheotomy incision. Tracheostomy tubes are often referred to "trach" for short.

Types Of Tracheostomy Tubes

Pediatric and Neonatal:

Usually tracheostomy tubes for infants and children up to 6 – 8 years of age are a single tube, uncuffed device. Trachesotomy tubes come in different diameters to fit different sized airways. This dimension is measured in millimeters (mm) and used to describe tracheostomy tube (ex: 3.5 mm) just as for ETT's.

Tracheostomy tubes also come in different lengths and optimize pediatric fit. This size is listed on product package. In general, Neonatal tracheostomies are shorter than Pediatric to fit very small infants. They are supplied in same diameters as Pediatric (ex: 3.5 Neonatal and 3.5 Pediatricare same diameter but different length, so check carefully). Pediatric tracheostomies also come in "extra long" (PDL) sizes.

Older children may have more "adult" type tracheostomy tubes with cuff that can be inflated to seal airway and decrease air leak around trachesotomy tube. Some larger trachesotomy tubes may also have inner cannula or a tube-within-a-tube. The inner cannula can be changed without changing the entire tracheostomy.

Various oxygenation and humidification sources can be used with trachestomy. These include trach mask and Easy Breather. Special one way speaking valves may also be attached. These will have to be removed for suctioning.

Manual ventilation bags (ex. Lardal) can be attached to tracheostomy tubes to assist the patient with ventilation and supply increased concentrations of oxygen.

A mechanical ventilator can also be attached to tracheostomy to provide oxygen, humidity, and ventilation assistance. The ventilator will need to be removed to suction patient, unless special in-line tracheostomy suction system is used.

2.2 Assessing the Need for Suctioning

2.2.1 Pediatric Considerations

A patient with a tracheostomy or endotracheal tube (ETT) is less able to increase intra-thoracic pressure needed for an effective cough to clear secretions. This is because the artificial airway bypasses the glottis which normally seals the airway allowing patient to exert a forceful cough.

Consequently, suctioning will need to be done when there are secretions present in the upper airways that the patient is unable to clear. Literature cautions that "routine" suctioning should be avoided as increases chances of mucosal trauma and infection. However, due to the small size of pediatric ETT or tracheostomy tubes, pediatric patients needed to be suctioned on a regular basis as small-sized tubes are more prone to obstruction from secretions. Build- up of secretions dramatically increases airway resistance, making it more difficult to breath.

Neonate/Pediatrics patients with endotracheal tubes are usually suctioned every 3-4 hours. Neonate/Pediatric patients with established tracheostomies may be suctioned less frequently, but at least in morning and evening to prevent tube obstruction. Remember that fine crackles and wheezes are rarely cleared with suctioning because they indicate narrowed bronchial passages, secretions or

edema in the small airways and alveoli, which are inaccessible to suctioning. Chest physiotherapy and postural drainage (positioning) may help move secretions from the lower airways to larger upper airways where it more accessible to suctioning.

2.2.2 Humidification

An ETT or tracheostomy bypasses the upper portions of the airway, where inspired gases are normally filtered and humidified.

Humidification of inspired air and adequate systemic hydration assist to:

- Keep secretions thin, easier to move/remove by coughing
- Prevent tube occlusion from thick/dried secretions
- Counteract insensible fluid losses
- Compensate for bypass of upper airway
- Maintain moist mucous membranes to maximize mucocilliary transport in the lower airways
- Humidity can be provided from extended sources such as heated humidifiers on mechanical ventilators or humidified gases via tracheostomy mask. Humidity can also be provided by special devised such as Easy Breathers or HME filters that trap exhaled moisture and utilize this to humidify next breath.

Complications of overhumidification are: excessive moisture into dependent bronchi, tracheal burns if humidity temperature is excessive, infection from contaminated humidity sources

2.3 Signs and Symptoms Indicating a Need for Suctioning

- Visible secretions in airway
- Change in respiratory pattern
- Increased respiratory rate and work of breathing
- Increased heart rate and cyanosis
- Restless and agitation
- Decreased SpO_2 and/or increased $ETCO_2$
- Ineffective coughing
- Course breath sounds, course crackles, noisy breathing and changes in air entry

Additional cues for Ventilated Patients

- Increased peak pressures during volume-controlled ventilation or decreased tidal volume in pressure controlled ventilation
- Changes in monitored flow or pressure graphics on ventilator

2.4 Contraindications to Suctioning an Artificial Airway

There are no absolute contraindications to suctioning an endotracheal or tracheostomy tube as secretions need to be removed to prevent obstruction. However, Neonate and

Pediatric patients with the following conditions are more likely to decompensate with suctioning. Suction these patients with caution and be ready to intervene.

- Increased intracranial pressure – cough/strain will increase ICP
- Hemodynamic instability – hypoxemia may result in hypotension, bradycardia and dysrhythmias
- Coagulopathy or bleeding disorders – suction to pre-measured depth only to minimize trauma to trachea
- Pulmonary hemorrhage
- Extreme reactive bradycardia (i.e. when the heart rate drops dramatically in response to vagal stimulation/hypoxemia produced with suctioning). Provide hyperoxygenation and suction to premeasured depth only.
- Hyperactive airways – coughing and irritation of suctioning produces bronchospastic and wheeze. Suction to premeasured depth only and give bronchodilators as ordered.

2.5 Preparing The Patient And Equipment For Suctioning

2.5.1 Preparing the Patient

Suctioning is an uncomfortable and often frightening procedure:

- The patient has an artificial airway and is therefore unable to vocalize
- Suctioning may cause hypoxemia
- The patient may have a smothered choking feeling making them anxious and restless/combative
- Patients have rated the pain of suctioning at 7 on a pain scale of 1-10

An explanation regarding the purpose of tracheal suctioning should be given to the patient and/or family prior to suctioning and throughout the procedure each time the procedure is done.

The patient needs frequent reassurance and instruction on how to assist during the procedure. Often the patient instinctively will pull at the tube and catheter, especially when the cough reflex is stimulated. Warn the patient that the procedure will make him/her cough. A second health care provider may be required to assist with procedure and help to protect artificial airway and manage patient status changes. (See unit specific policy/standards.)

2.5.2 Positioning the Patient

Ideally, the mechanically ventilated patient with an artificial airway (ETT or tracheostomy) will have the head of bed, elevated 30^{o} at all times. This is shown to decrease the incidence of ventilator acquired pneumonias (VAP'S) by reducing aspiration.

For all patients, during suctioning position with the head of bed elevated 30^{o} or in appropriate position for postural drainage unless medically contraindicated (i.e.

unstable spinal fractures).
This promotes deep breathing and effective coughing by allowing maximum movement of the diaphragm.

2.5.3 Hyperoxygenation

Hyperoxygenation refers to the administration of oxygen at a greater concentration than the patient is receiving or usually requires. It is performed before, during, and after suctioning, based on assessment of the patient's respiratory status. Hyperoxygenation can be performed by:

- giving 5-6 ventilations using a manual ventilation bag with supplemental O_2
- having the patient taking several large breaths while receiving a higher than normal concentration of oxygen
- In the ventilated patient: increasing the ventilator FiO_2 prior to suctioning. Note: To give 100% oxygen by ventilator requires 1-2 minutes before circuit in the ventilator is completely filled with high-concentration O_2.

Rationale: It is well documented that a decrease in arterial oxygenation occurs during the tracheal suctioning procedure that may cause cardiac dysrhythmias, especially bradycardia and hypotension. Hyperoxygenation minimizes suction-induced hypoxemia by creating an oxygen reservoir in alveoli.

Note: Long term, stable tracheostomy patients on low concentrations of oxygen or room air may not require any hyperoxygenation. Careful patient assessment needs to be provided during each suctioning procedure.

2.5.4 Lung Recruitment Maneuvers (LRM's)

Lung Recruitment Maneuvers are strategies used in critically ill ventilated patients to maintain "open alveoli". The negative suction pressures applied during suctioning pull air out of aveoli and contribute to collapse and atelectasis. Lung Recruitment Maneuvers utilize increased positive airway pressures on inspiration and/or expiration (eg. peak pressures, PEEP) or increased volumes during and after suctioning to minimize this collapse. These parameters are ordered by physician. (Maggorie et al. 2003)

2.6 Preparing the Equipment

2.6.1Suction Catheters

Suction catheters come in a variety of sizes and configurations. Straight suction catheters are designed for "open-suction" where patient is removed from O_2 source or ventilator in order to suction. These catheters are equipped with a suction control port, which when occluded, enables negative pressure from the suction source to be transmitted through the catheter. This port usually occluded

(ie suction applied) once the catheter has been advanced into the ETT or trach. The size of catheters will vary depending on the size of the ETT or tracheostomy.

Size of Catheters

Adolescents	#12-14 Fr. catheters
Pediatrics	#8-14 Fr. catheters
Neonates	#6-8 Fr. catheters

Endotracheal/Tracheostomy Tube and Suction Catheter Chart

Endotracheal/Tracheostomy Tube (inner diameter in mm)	Suction Catheter Size (French)	In-Line Suction Catheter (French)
2.5	5	6
3.0	6	6 or 8*
3.5	6	8*
4.0	8	8*
4.5	8	10
5.0	10	10
5.5	10	10
6.0	12	12
6.5	12	12
7.0	14	14*
8.0	14	14*

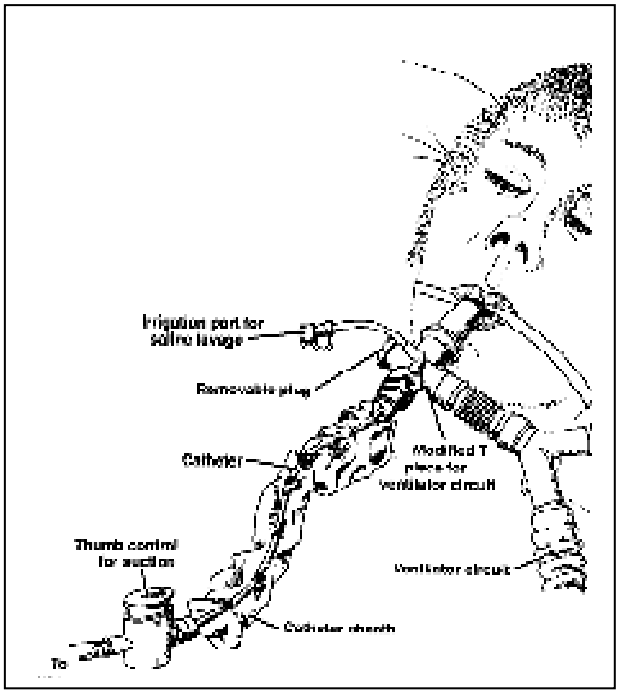
***These sizes available as In-line suction catheters for Tracheostomy tubes**

The catheter size should be no more than 2/3 of the diameter of the airway to prevent hypoxemia and atelectasis. [3.5] (Singh et al. 1991; Chong et al. 2003) However, if secretions are very thick and/or copious, use larger suction catheter to minimize number of suction passes and ensure secretions are cleared.

2.6.2Closed System or In-Line

In ventilated patients with ETT or tracheostomy a closed- circuit catheter system eliminates the need to disconnect the patient from the ventilator during suctioning. This system is recommended for patients with high oxygen needs or increased levels of PEEP as the severity of desaturation and derecruitment of alveoli is reduced by providing less interruption to positive ventilatory pressures and PEEP. In-Line suction also minimizes aresolization of contaminated secretions and may decrease risk of nosocomial infections[2] (Curley & Thompson 2001). Refer to Policy and Procedure: *Suctioning Ventilated (Conventional and High Frequency) Patients via Artificial Airways: Pediatric/Neonate, #1056 (Appendix A).*

Closed suction systems may require increased suction pressure to effectively remove secretions. However, suction pressure should not exceed 180mmHg unless ordered by physician.


Irrigation port for saline lavage
Removable plug
Catheter
Modified T piece for ventilator circuit
Thumb control for suction
Ventilator circuit
Catheter sheath
To

2.6.3 Suction Pressure

Adjust the suction pressure according to the nature of the secretions being removed, using the lowest suction pressure that will be effective. Set suction pressure at:

- Pediatrics 100 – 120 mmHg
- Neonates 80 – 100 mmHg

Thick secretions or mucous plugs may necessitate pressures at higher end of range.

Rationale: Damage to the epithelial and mucosal layers of the airways caused by the presence of an artificial airway is magnified with the introduction of a suction catheter. Excessive negative pressure causes edema, hemorrhage, and ulceration of tracheal tissue. Negative pressures also pull air from distal airways contributing to atelectasis and decreased lung compliance. (Chong et al 2003)

2.6.4 Instillation

The instillation of sterile 0.9% saline should not be done on a routine basis but may be required for tenacious secretions. Adequate systemic hydration and airway humidification need to be provided to prevent thick secretions. Normal saline and secretions do not mix together. Therefore, instillation provides a lavage and/or stimulates a cough that moves secretions. Instillation may have adverse effect on oxygenation and may promote infection by washing bacteria from artificial airway into lower airway tracts. (Curley & Thompson 2001; Ridling et al, 2003)

If required, instill sterile 0.9% saline into the tube, during inspiration:

- Neonates 0.3 – 1 ml
- Infant 0.5 – 1.5 ml
- Child 1.5 – 2 mls
- Adolescents – 2 – 3 mls

Instillations must be kept sterile. Solutions opened or drawn up at bedside must be discarded after 24 hours (NICU – 12 hours).

2.6.5 Measured Suction Depth

All routine suction passes should be to pre-measured depth to minimize risk of trauma to delicate tracheal tissues. Repeated suctioning past end of endotracheal or tracheostomy tube can result in bronchial perforation, hemorrhage, histological changes, airway inflammation and tracheal stenosis. The suction catheter should not pass beyond distal end of endotracheal or tracheostomy tube on a regular basis. (Curley & Thompson, 2001) **Suction Catheters should never be inserted until resistance felt, as this causes trauma to carina and may precipitate pulmonary hemorrhage. If tube**

obstructed with secretions – may suction 0.5 to 1 cm beyond measured depth with caution.

Endotracheal Tube Measurement:

- Suction depth can be measured by noting cm markings on endotracheal tube visible at teeth or gums, then adding length of endotracheal tube external to patient and adapter to this. This measurement should not need adjustment with tube depth adjustments as entire tube moves up or down. This measure will, however, need adjustment if endotracheal tube is cut.
- For In-line suction catheters: size 6, 8, 10 French- measure as above or add 5 cm to last visible cm. marking on tube for approximate suction depth to adapter external end.

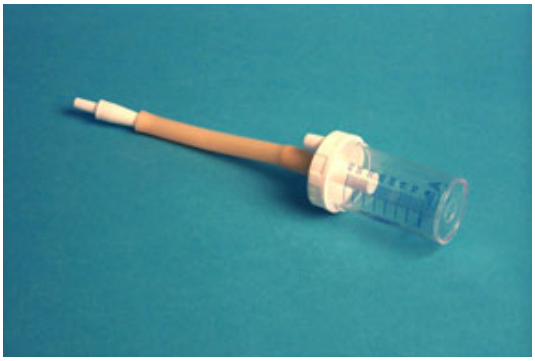
Tracheostomy Tube Measurement:
Use length of tracheostomy tube indicated on box plus measured distance of tracheostomy above stoma (add length of adapter if used). Length of obturator may also be used calculate suction depth but will be slightly longer than tracheostomy tube.

Note: Suction Depth measurement should be posted at bedside of all pediatric patients and documented on patient care plan. Suction catheter should only be inserted to this depth on regular basis. Utilize cm. markings on catheter, bedside measuring tape, or color-coded bars on in-line catheter to determine suction depth.

2.6.6 Obtaining Specimens

- A suction trap and straight, sterile suction catheter (with open-suction technique) is used to collect sterile sputum specimens from endotracheal or tracheostomy tube for culture and sensitivity (C &S), acid fast bacilli (AFB) and other diagnostic tests.
- If using in-line catheter, ensure new, sterile catheter utilize for specimen collection. (SHR Laboratory Manual 2005)
- The specimen trap is placed between the suction catheter and the suction tubing.
- Please see SHR Infection Prevention and Control Manual and Laboratory Service Manual for further information regarding use of sputum traps.

Note: Use open suction technique or new in-line suction for C & S specimens from ventilated patients.



2.7 Complications of Tracheal Suctioning

	Symptoms	Prevention
• Hypoxemia / Hypoxia	• Decreased oxygen saturation (SaO_2 < 90% or below patient's baseline) • Cyanosis • Cardiac dysrrhythmias: tachycardia or bradycardia • Premature ventricular contractions • Cardiorespiratory arrest	• Limit suction pressure to: 100 – 120 mmHg for adults 80 – 100 mm Hg for children 50 - 80 mmHg for neonates • Limit duration of suctioning to: 10 -15 sec. for adults, 10 sec. for children, 5 sec. for neonates • Avoid catheters larger than 2/3 the diameter of the airway • Hyperoxygenate & / or hyperventilate prior to suctioning • Avoid routine suctioning – suction only as needed • Limit number of catheter passes
• Cardiac Dysrrhythmias / Arrest	• Tachycardia - decreased arterial oxygen content • Bradycardia - Vagal response	• Minimize hypoxemia by pre-oxygenating • Suctioning quickly (5 seconds for continuous, 10 seconds for intermittent) • Stop suctioning administer 100% oxygen by manual ventilation or ventilator
• Tracheal Mucosal Damage • Pulmonary Hemorrhage	• Aspiration of blood tinged mucous • Decreased air entry • Aspiration of frank blood	• Advance catheter pre-measured distance only • Use lowest level of suction pressure that will be effective • Perform suction procedure gently • Avoid forcing the catheter against resistance • Limit number of catheter passes • Avoid routine suction - suction only as needed • Assess patient coagulation status
• Infection: patient, caregiver	• Increased secretions in the trachea • Colonization with gram-negative organisms • Increased heart rate, respiratory rate, and temperature	• Ensure adequate humidification of gases • Wash hands before and after procedure • Use sterile equipment and solutions • Maintain strict aseptic technique

	Symptoms	Prevention
		• Keep ends of oxygen source clean to reduces possibility of contamination of the oxygen source • Use gentle suctioning technique to avoid trauma (monitor suction pressure, duration and depth) • Optimal hydration, nutritional and metabolic status • Avoid routine suctioning - suction only as needed • For staff protection: use of gloves, masks, goggles is required • Change respirate supplies per Infection Control parameters
• Hypotension / hypertension	• Significant change from baseline BP	• Stop suctioning • Oxygenate and ventilate • Prepare patient for suctioning • Increase analgesic/sedation if appropriate
• Atelectasis	• Decreased air entry • Change in chest x-ray	• Limiting amount of negative pressure used (see hypoxia section) • Keep duration of suctioning as short as possible (see hypoxia section) • Provide Lung Recruitment Maneuvers (LRM's) after suctioning as ordered • Appropriate size of suction catheter
• Bronchoconstric-tion / Bronchospasm • Paroxysmal Coughing	• Change in air entry • Wheezes auscultated	• Administer bronchodilators as ordered. May need to do prior to suctioning or give routinely • Ensure manual ventilations in "sync" with patient's respiratory effort • Talk to patient to calm them

• Obstruction	• Unable to ventilate patient
	• Unable to suction patient
		• Call for help then:
		<u>ETT</u>:
		  • Remove ETT airway and face bag with 100% O_2
		<u>Tracheostomy</u>:
		  • Change tracheostomy tube
		• Use manual ventilation to administer extra O_2 until stable

	Symptoms	Prevention
• Increased Intracranial Pressure >20 mmHg x 5 min or >25 mmHg for any time or outside physician established parameters	• may correspond with increased BP & coughing	• Increase analgesia/sedation as ordered • Give IV Lidocaine prior to suctioning as ordered • Give Thiopental IV prior to suctioning as order • Considered neuromuscular blocking agent (chemical paralysis) as ordered (ventilated patient only!)

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4.0 APPENDICES

APPENDIX A - Policies

Saskatoon Health Region	POLICIES & PROCEDURESS Title: **SUCTIONING – NON-VENTILATED PATIENTS WITH TRACHEOSTOMY: PEDIATRIC/NEONATE** I.D. Number: **1051**
Authorization [ ] Pediatric Operations Committee [x] Tri-Hospital Nursing Practice Committee	Source: Cross Index: Date Reaffirmed: Date Revised: Date Effective: May, 2006 Scope: **SASKATOON CITY HOSPITAL – ER, OR, PACU** **ROYAL UNIVERSITY HOSPITAL – 3000, 3100, NICU, PICU, ER, OR, PACU** **ST. PAUL'S HOSPITAL – ER, OR, PACU** **PARKRIDGE**

1. POLICY

1.1 The RN, RRT, PT and their students (with supervision) may perform suctioning of the non-ventilated patient who has a tracheostomy tube in order to remove airway secretions as necessary. For patients with fresh tracheotomies (i.e. tracheostomy tube has not bee changed), 2 qualified persons are required to suction to prevent dislodgement of tracheostomy tube.

1.2 Senior Assistants and LPN's may suction *stable* non-ventilated and stable long-term ventilated patients with an *established* tracheostomies as assigned by RN once completing unit specific Additional Skills Certification Package in targeted units.

1.3 Sterile suction technique must be used for tracheostomies the first 14 days post-operative and for obtaining specimens for diagnosis (sterile suction catheter and sterile gloves.) Modified sterile suction technique may be used for established tracheotomies more than 14 days post-operative (sterile suction catheter and clean gloves without touching portion of suctioning catheter entering tracheostomy tube)[1].

1.4 Routine suctioning should be done to premeasured depth. This distance (in cm.) should be measured prior to suctioning and documented in Patient Care Plan and posted at bedside.

2. PURPOSE

To maintain airway patency by removing pulmonary secretions from the trachea of a patient with a tracheostomy as a component of bronchial hygiene. This decreases the risk of hypoxia and potential for infection. It also enables collection of sputum for diagnostic purposes.

3. PROCEDURE

3.1 Assess the patient's need for suctioning by observing and auscultating for:

- Increased respiratory rate and work of breathing
- increased heart rate or cyanosis
- decreased SpO_2
- coarse breath sounds, crackles, changes in air entry
- vibrations of secretions in chest
- coarse crackles, coarse breath sounds, changes in air entry
- coughing
- visible secretions in airway

Suctioning should be done on the basis of clinical assessment, with a minimum of morning and bedtime (and usually prior to feeds/meals) to ensure patency of tracheostomy tube[1]

3.2 Ensure that the following equipment is at the bedside and in good working order:

- manual resuscitation bag with reservoir, attached to an oxygen flow meter
- face mask of appropriate size
- suction regulator
- suction catheters of appropriate size
    - Neonate 6 – 8 Fr.
    - Pediatrics 8 – 12 Fr.
    - Adolescents 12 – 14 Fr

NOTE: Usually a suction catheter of 2/3 diameter of tracheostomy tube is recommended. However, if secretions are thick or copious, use a larger suction catheter to minimize number of suction passes and ensure secretions are cleared. [1.6]

- suction canister and connecting tubing
- mask face shield
- sterile gloves for tracheostomy < 14 days post-op
- clean gloves for tracheostomy > 14 days post-op
- tonsiller suction for oral secretions
- mouth care supplies
- stethoscope

3.3 Wash hands

3.4 Explain procedure to patient as appropriate to developmental level.

3.5 Position patient with head of bed elevated 30^{o} or in appropriate position for postural drainage, unless contraindicated.

3.6 Put on mask and protective eye wear/face shield.

3.7 Set up sterile saline for instillation (if required) and flushing of catheter between catheter passes.

3.8 Assess the need for instillation with sterile 0.9% saline.
Routine instillation is not recommended as has an adverse effect on oxygen saturation but may be required if secretions very thick.[1.5]

Recommended volumes:	Neonate	0.3 – 1 ml
	Infant	1 – 1.5 ml
	Child	1.5 – 2 ml
	Adolescent	2 – 3 ml

NOTE: Maintain sterility of instillation solution and change solutions at least q24 hours. NICU: q 12 hours.

3.9 Open suction catheter package maintaining the sterility of catheter. Attach catheter end to connection tubing from the suction apparatus. Adjust wall suction to 80 – 120 mmHg for pediatrics and 50 – 80 mmHg for neonates.
Put on gloves (sterile or clean) as per 1.3.

3.10 Disconnect the patient from humidity, oxygen source or ventilator ensuring the connections are kept clean.

3.11 Preoxygenate patient if requiring high supplemental O_2 or severely desaturating as routine manual ventilation may force secretions back into distal airways.[1]

3.12 Without applying suction, advance catheter to pre-measured suction depth. (See Appendix B).

3.13 Apply suction while withdrawing and rotating the catheter
NOTE: Duration of suctioning should not exceed 5 seconds when continuous suction applied or 10 seconds for intermittent suction.

3.14 Between passes, allow the patient to rest and reoxygenate by reconnecting patient to oxygen source or ventilator. Hyperoxygenation with manual resuscitation bag and high flow oxygen may be required if SpO_2 is low, patient is cyanotic or showing other signs of severe respiratory distress. Patients prone to atelectasis

may benefit from hyperinflation with manual resuscitation bag following removal of secretions [1] as ordered by physician.

3.15 If further suctioning is required, repeat procedure from 3.10 – 3.14. Allow the patient to rest and reoxygenate between suction passes.

3.16 Clear the catheter and connecting tubing with sterile normal saline before reinserting and at the end of procedure.

3.17 The mouth/nose may be suctioned with the same catheter used for tracheal suctioning, provided the mouth/nose is suctioned last.
NOTE: The mouth/nose is considered contaminated with normal bacterial flora. Oral/nasal suctioning should never precede tracheal suctioning if the same catheter is used.

3.18 Auscultate the chest to determine effectiveness of suctioning and ensure patient stability, comfort and safety.

3.19 Document on appropriate record:

- amount, color, and consistency of secretions
- patient's tolerance of procedure, vital sign changes
- actions taken if problems encountered during suctioning
- air entry and breath sounds before and after suctioning
- specimen(s) obtained and sent

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APPENDIX A: Endotracheal/Tracheostomy Tube and Suction Catheter Chart

Endotracheal/Tracheostomy Tube (inner diameter in mm)	Suggested Suction Catheter Size (French) (Note: Approximate 2X Tube Size)
2.5	5
3.0	6
3.5	6
4.0	8
4.5	8
5.0	10
5.5	10
6.0	12
6.5	12
7.0	14
8.0	14

APPENDIX B: Measured Suction Depth

- All routine suction passes should be to pre-measured depth to minimize risk of trauma to delicate tracheal tissues. Repeated suctioning past end of tracheostomy tube can result in bronchial perforation, hemorrhage, histological changes, airway inflammation and tracheal stenosis.
- Suction catheter should not pass beyond distal end of the tracheostomy tube on a regular basis. Special circumstances (copious thick secretions or partially obstructed tracheostomy tube) may warrant occasional uses of deeper suctioning (ie. 0.5 past the pre-measured depth) to remove secretions adhered to tip of tracheostomy tube. **However, avoid inserting suction catheter until resistance is felt, as this causes trauma to carina.**

To Measure:

- Use length of tracheostomy tube indicated on box plus measured distance of tracheostomy above stoma (add length of tracheostomy adapter if used). Length of tracheostomy obturator maybe used, however, it is slightly longer than tracheostomy tube.
- Suction Depth measurement is posted at bedside and documented on patient care plan. Suction catheter should only be inserted to this depth. Utilize cm markings on catheter or bedside measuring tape to determine suction depth with each suction pass.

Saskatoon Health Region	POLICIES & PROCEDURESS Title: **SUCTIONING - <u>VENTILATED</u> (CONVENTIONAL AND HIGH FREQUENCY) PATIENTS VIA ARTIFICIAL AIRWAYS: PEDIATRIC/NEONATE** I.D. Number: **1056**
Authorization [ ] Pediatric Operations Committee [X] Tri-Hospital Nursing Practice Committee	Source: Cross Index: Date Reaffirmed: Date Revised: Date Effective: March, 2006 Scope: **Saskatoon City Hospital – ER, OR** **Royal University Hospital – NICU, PICU, ER, OR** **St. Paul's Hospital – ER, OR**

1. POLICY

1.1 The RN, RRT, experienced PT and their students (with direct supervision) may perform suctioning of the ventilated pediatric patient who has an endotracheal tube or tracheostomy tube as necessary. (Pediatric patients are patients under 17 years of age.)

1.1.1 NICU patients are suctioned by RNs or RRTs.

1.1.2 PICU patients require 2 qualified personnel for suctioning unless otherwise ordered (second person to monitor vital signs and ensure airways stability).

1.2 Suction depth should be measured prior to suctioning and distance (in cm) documented in Patient Care Plan and posted at bedside.

1.3 Collection of Specimens for C&S: use an open-suction technique or a new in-line suction catheter.

2. PURPOSE

2.1 To maintain airway patency by removing pulmonary secretions or foreign matter from trachea in patient with an artificial airway as a component of bronchial hygiene and mechanical ventilation. This decreases the risk of hypoxemia and potential for infection. It also enables collection of sputum for diagnostic purposes.

2.2 Suctioning may utilize closed or open technique.

2.2.1 Open technique – patient disconnected from ventilator and suctioned with regular suction catheter.

2.2.2 Closed technique – utilizes an in-line suction catheter with patient remaining attached to ventilator and is recommended for patients with high oxygen requirements or increased levels of PEEP. Closed technique reduces recruitment of alveoli and subsequent atelectasis.[1,2] It also minimizes aerosolization of contaminated secretions and may prevent nosocomial infections[2].
NICU/PICU – Closed suctioning is standard of care for endotracheal tube suctioning,[9] except for emergency situations where endotracheal tube is obstructed and in-line suction has not relieved obstructions or specimen for C&S is required.

3. PROCEDURE

3.1 Assess the patient's need for suctioning by observing and auscultating for:
- increase RR and work at breathing
- decreased SpO_2 and/or increases in $ETCO_2$.
- increased heart rate or cyanosis
- restlessness or agitation
- coarse breath sounds, crackles, noisy breathing & changes in air entry
- coughing
- visible secretions in airway
- increased peak pressures during volume-controlled ventilation or decreased tidal volume during pressure-controlled ventilation
- changes in monitored flow or pressure graphics on ventilator

3.2 Assess the need for instillation with sterile 0.9% saline. Instillation may be indicated in patients with tenacious secretions but should not be done routinely as has adverse effect on oxygenation and may promote infection. [2,3]

Recommended volumes:	*Neonate*	*0.3 – 1 ml*
	Infant	*1 – 1.5 ml*
	Child	*1.5 – 2 ml*
	Adolescent	*2 – 3 mls*

Instillation solutions must be kept sterile. Solutions opened or drawn up at bedside must be discarded after 24 hours (NICU after 12 hours).

3.3 Ensure that the following equipment is at the bedside and in good working order:

- oxygen flow meter
- manual resuscitation bag with reservoir and face mask of appropriate size
- suction regulator
- suction catheters of appropriate size [usually 2 times the diameter of the endotracheal or tracheostomy tube (in mm.) equals the appropriate French sized catheter. [See Appendix A]
  - Neonates 5 – 8 Fr.
  - Pediatrics 8 – 12 Fr.
  - Adolescents 12 – 14 Fr.
  - *NOTE: Catheter should be no more than 2/3 of lumen of tube to prevent hypoxemia and atelectasis.*[2,4,6] *However, if secretions are very thick and copious, use larger suction catheter to minimize number of suction passes and ensure secretions cleared.*[2,5]
- suction canister and connecting tubing
- 0.9% saline for instillation
- mask, sterile gloves, face shield for open suction
- clean gloves for closed suction
- mouth care supplies
- stethoscope
- monitoring equipment (if possible) HR & SaO_2

3.4 Wash hands

3.5 Explain procedure to patient if appropriate, incorporating development care practices.
(Appendix B)

3.6 *Position patient with head of bed elevated 30^o supine and head midline, unless contraindicated.*
Note: Elevation of head of bed to 30^o is recommended for all intubated pediatric patients in supine or side-lying positions.

3.7 <u>Open Tracheal Suctioning Procedure</u>

3.7.1 Put on mask and protective eye wear/face shield.

3.7.2 Set up sterile 0.9% saline for instillation and for flushing of catheter between catheter passes.

3.7.3 Open suction catheter package maintaining the sterility of catheter. Attach catheter end to connection tubing from the suction apparatus. Adjust wall suction. Recommended pressures should

not exceed 80 – 120 mmHg for pediatrics and 80 – 100 mmHg for neonates.

3.7.4 Put on sterile gloves.

3.7.5 Hyperoxygenation: Disconnect the patient from the ventilator ensuring ventilator connections are kept clean. Pre-oxygenate patient by ventilating for 3 – 5 breaths using a manual resuscitation bag and 100% oxygen.

NICU: Hyperventilate at rate 10-20% above baseline.

NOTE: Hyperoxygenation provides an oxygen reserve in the alveoli, reducing the risks of hypoxemia and bradycardia.

3.7.6 With sterile gloved hand, advance catheter to pre-measured depth without applying suction. Utilizing measured depth ensures suction catheter does not extend beyond end of endotracheal tube or tracheostomy tube and cause trauma. (See Appendix C for how to measure suction depth).

NOTE: *In specific circumstances, such as suspected endotracheal tube obstruction, catheter may be advanced 0.5 cm beyond pre-measured depth to remove secretions adhered to distal end of endotracheal tube.*

3.7.7 Apply intermittent suction while slowly withdrawing the catheter, rotating catheter between the finger and thumb. Continuous suction may be warranted with thick, copious secretions or meconium aspiration.

NOTE: Duration of <u>intermittent</u> suction should not exceed 10 seconds in pediatric patients or 5 seconds in neonate. Duration of <u>continuous</u> suction should not exceed 5 seconds in neonate or pediatric patient.

3.7.8 Reoxygenate with the manual resuscitation bag for a minimum of 3-5 breaths at age appropriate rate or until SaO_2 returns to baseline for 30 seconds.

NICU: manually ventilate at rate 10 – 20% higher than ventilation parameters with FiO_2 to keep oxygen saturation within ordered parameters between suction passes.

NOTE: A drop in paO_2 occurs during suctioning and after disconnection from the ventilator. Hyperoxygenation and hyperventilation before and after suctioning minimizes this drop.

3.7.9 If further suctioning is required, repeat procedure from 3.7.6 – 3.7.8. Allow the patient to rest and reoxygenate as necessary.

3.7.10 Clear the catheter and connecting tubing with sterile normal saline as needed and before inserting catheter at the end of procedure.

3.7.11 Reconnect patient to ventilator when suctioning completed.

3.7.12 The mouth/nose may be suctioned with the same catheter used for tracheal suctioning, provided the mouth/nose are suctioned last. *NOTE: The mouth/nose are considered contaminated with normal bacterial flora. Oral/nasal suctioning should <u>never</u> proceed tracheal suctioning if the same catheter is used.*

3.7.13 Auscultate the chest to determine the effectiveness of suctioning and ensure patient comfort and stability.

3.7.14 Document on appropriate record:

- amount, color, and consistency of secretions.
- patient's tolerance of procedure, vital sign changes.
- actions taken if problems encountered during suctioning
- air entry and adventitious breath sounds
- specimen(s) obtained and sent

3.8 <u>The Closed Tracheal Suctioning Procedure – Pediatrics/Neonates</u>

<u>Note:</u> for C&S specimens, use new In-line suction catheter or open suction technique
<u>Note:</u> Tracheosotmy specific In-line suction catheters may be utilized with tracheostomy tubes.

3.8.1 Put on clean gloves. Set wall suction to Pediatrics 120 mmHg, (may increase wall suction to 180 mmHg for very thick secretions) Neonate 100 mmHg.

3.8.2 Monitor patient for disrythymias, changes in heart rate, or SaO_2 while suctioning.

3.8.3 Preoxygenate patient for 1 minute using the 100% oxygen key on the ventilator.

NICU: Preoxyenate by increasing F_1O_2 0.1 to 0.2 above baseline.

Some patients may require longer duration of reoxygenating to achieve maximum oxygenation.

NOTE: RRT to adjust ventilator settings as ordered for lung recruitment maneuvers (LMR's)..

3.8.4 Determine correct color or number for suction depth (See Appendix C)..

3.8.5 Unlock in-line suction. Instill if required via Instillation/Irrigation port.

3.8.6 Stabilize the catheter and endotracheal or tracheostomy tube with non-dominant hand.

3.8.7 Without suction, advance catheter to premeasured depth while pulling plastic sheath back.

3.8.8 Depress the control valve to apply suction. Maintain suction while withdrawing the suction catheter fully, while stabilizing endotracheal or tracheostomy tube to prevent dislodgement. Ensure catheter tip fully retracted at end of suctioning to prevent obst5ruction of endotracheal or tracheostomy tube.

Note: Duration of suctioning will not exceed 5 seconds as continuous suction recommended

3.8.9 Check viewing port for secretions and assess patient. If further suctioning is required, repeat procedure from 3.8.6 – 3.8.8. Allow the patient to rest and reoxygenate between suction passes.

3.8.10 Clean the catheter of debris by flushing sterile 0.9% saline via the irrigation port while simultaneously applying suction. Close suction control valve.

Note: Catheter changed when debris cannot be cleared with flushing as above.

3.8.11 Return ventilator to baseline parameters, decreasing FiO_2 according to SaO_2 and clinical status.

3.8.12 Cap the irrigation port. Discard any unused normal saline. Disconnect suctioning from in-line suction catheter and re-cap in-line catheter end. Provide mouth care per unit policy.

3.8.13 Auscultate chest to determine the effectiveness of suctioning, ensure patient stability, comfort and safety.

NOTE: If Lung Recruitment Measures (LRM's) have been implemented, RRT to return ventilator settings to pre-suction baseline as ordered. [9]

3.8.14 Document on appropriate record:

- Amount, color and consistency of secretions
- Patient's tolerance of procedure, vital sign changes
- Actions taken if problems encountered during suctioning
- Air entry and adventitious breath sounds
- If specimen sent

3.8.15 Change suction catheter
PICU: When visible debris cannot be cleared with irrigation
NICU: q weekly as indicated in Patient Care Plan

3.9 Suctioning Patients Receiving High Frequency Ventilation: Oscillating (HFOV) or Jet (HFJV)

3.9.1 Cues for suctioning and primarily based on visualization of secretions in endotracheal tube, changes in vital signs, decrease in chest vibrations (decreased chest wiggle factor) as distinct breath sounds will not be heard due to rapid frequencies or ventilation.

3.9.1.1 With HFOV, frequency of suctioning should be minimized, based on decreased chest wiggle factor (no more than every 12 to 24 hours).

3.9.1.2 With HFJV, Increase in Servo pressure may indicate need for suction.

NOTE: RRT should be present when patients receiving HFOV or HFJV are suctioned as ventilators put in "Standby" modes and may require adjustments following suctioning procedure, such as increased MAP (mean airway pressures) to re-open collapsed alveoli.

3.9.2 Pre-oxygenation and instillation should be based on patient needs as per 3.7.5 and 3.8.3. Suctioning is done utilizing pre-measured suction depth (See Appendix C).

3.9.3 Suctioning Procedures

3.9.3.1 HFOV:

- In-line suction (closed suction technique) should always be utilized. Ventilated disconnects should be avoided to prevent decruitment of alveoli.
- Ventilator put into "Standby" more per RRT during suction passess, and then turned back on by pressing the "Reset" button between suction passess to restart ventilator to oxygenate patient.
- Follow In-line suction procedures per 3.8. However, suction should be applied both during insertion and withdrawal of suction catheter, unless ordered otherwise. Withdrawal of catheter should be in a slow, rotating manner (5 to 10 seconds) to minimize effects of negative pressures caused by suctioning.

3.9.3.2 HFJV:

- Open suction technique is utilized as per 3.7 as ETT adapter cannot accommodate in-line suction catheter.
- HFJV may be reconnected between suction passes to provide oxygenation/ventilation, or use manual ventilation unit with flow oxygen and PEEP valve to oxygenate/ventilate between suction passes.
    - *NICU: Use of Neopuff*
- Follow Open Suction procedures per 3.7. However, suction should be applied both during insertion and withdrawal of suction catheter, unless ordered otherwise. Withdrawal of catheter should be in a slow, rotating manner (5 to 10 seconds) to minimize effects of negative pressure caused by suctioning.

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APPENDIX A: Endotracheal/Tracheostomy Tube and Suction Catheter Chart

Endotracheal/Tracheostomy Tube (inner diameter in mm)	Suction Catheter Size (French)	In-Line Suction Catheter (French)
2.5	5	6
3.0	6	6 or 8*
3.5	6	8*
4.0	8	8*
4.5	8	10
5.0	10	10
5.5	10	10
6.0	12	12
6.5	12	12
7.0	14	14*
8.0	14	14*

***These sizes available as In-line suction catheters for Tracheostomy tubes**

APPENDIX C: Measured Suction Depth

- All routine suction passes should be to pre-measured depth to minimize risk of trauma to delicate tracheal tissues. (bronchial perforation, hemorrhage histological changes, airway inflammation and stenosis)
- Suction catheter should not pass beyond distal end of endotracheal or tracheostomy tube on a regular basis. Catheter should never be inserted up to carina.
- For Endotracheal Tube: Suction depth can be measured by noting cm markings on endo tracheal tube then adding length of adapter.
  For Tracheostomy Tube: Use length indicated on box or length of obturator plus measured distance of tracheostomy above stoma (add length of adapter if used).
- This measured depth is posted at bedside and documented on patient care plan. Suction catheter should only be inserted to this depth. Utilize cm markings on catheter or color coded bars on in-line suction catheter.

Appendix B: Essential Anatomy & Physiology of Pediatric Respiratory System (Curley & Thompson. 2001)

Immaturity of the respiratory system places the infant and young child at risk for respiratory dysfunction with respiratory failure being primary factor in cardiopulmonary arrest.

1. Embryology

- Pulmonary function is immediately essential for extrauterine life. Gestational age of premature babies has dramatic influence on immediate and long term respiratory issues.
- Embryological development has 5 stages reflecting histological maturation of lung:
  - Embryonic Period (Day 26 – 52) – primitive forgut divides into trachea and esophagus with bronchial "buds" beginning to shape bronchial branches and main lung lobes.
  - Pseudoglandular Period (52 days – 16 weeks) – major conducting airways and terminal bronchi formed. Arterial supply increases. Diaphragm forms from pleuroperitoneal folds at 8 – 10 weeks gestation.
  - Canalicular Period (17 – 24 weeks) – bronchioles develop with 2 -3 thin walled terminal sacs (primitive alveoli) on each
  - Saccular Period (28 – 36 weeks) – intense vascularization of lung and loss of glandular appearance. Elastic fiber, important for alveolar development, develop (true alveoli present at 34 weeks). Contact between air spaces and capillaries established. Lymphatic capillaries develop. Gas exchange possible but not optimal.
  - Alveolar Period (36 weeks – term) – formation of true alveoli occurs, with one type of cell for gas exchange (90%) and another type for surfactant secretion. Surfactant is a complex lipid substance lowering lung surface tension which aids in lung inflation. Surfactant production is primarily during 38 – 40 weeks, so opening of alveoli before this may be difficult and traumatic.

Pulmonary system continues to develop until at least 8 years of age and possibly into adolescence by:

- Increase in size (4 times) and number of alveoli (10 times) resulting in air surface interface increase of 20 times (24 million alveoli at birth; 200 – 600 million alveoli in adult)
- Tracheal diameter increase 3 times in first 12 months
- Lung volume increases 4 times

2. Thoracic Cavity

Ribs, vertebrae and sternum provide framework for thoracic cavity containing lungs (right lung – 2 lobes; left lung 3 lobes), as well as trachea, heart, great vessels (aorta and pulmonary artery and vena cavas) and esophagus.

- Thoracic cavity lined with parietal pleura. Lungs encased with visceral pleura. Lubricating fluid in pleural space between them.
  In disease states, pleural space may fill with air (pneumothorax), blood (hemothorax), fluid (pleural effusion), lymph (chylothorax) or pus (empyema).

- Shape of thoracic cavity changes with maturation from round in infant to adult shape at 6 years of age.

- Diaphragm is main respiratory muscle in child, producing most of the inspiratory effort.
  - Phrenic nerve supplies motor and sensory functions primarily from 3, 4 & 5^{th} cervical spinal nerves.
  - Reliance on primarily one muscle for respiratory makes infants and children more prone to fatigue when rapid rates must be sustained

- Intercostal and accessory muscles poorly developed in infant so contribute little to respiratory effort. Infant uses abdominal muscles to assist with breathing.

- Chest wall very compliant as ribs primarily of cartilage and very flexible in infant and young child.
  - With increased inspiratory effort (downward movement of diaphragm) chest wall will move inward on inspiration resulting in indrawing between ribs (intercostal), below sternum (substernal) and at base of trachea (tracheal tug). This is a sign of increasing respiratory effort and distress.
    In extreme circumstances, a “see-saw” or paradoxical movement of chest and abdomen may also result (an ominous sign of impending respiratory Failure).

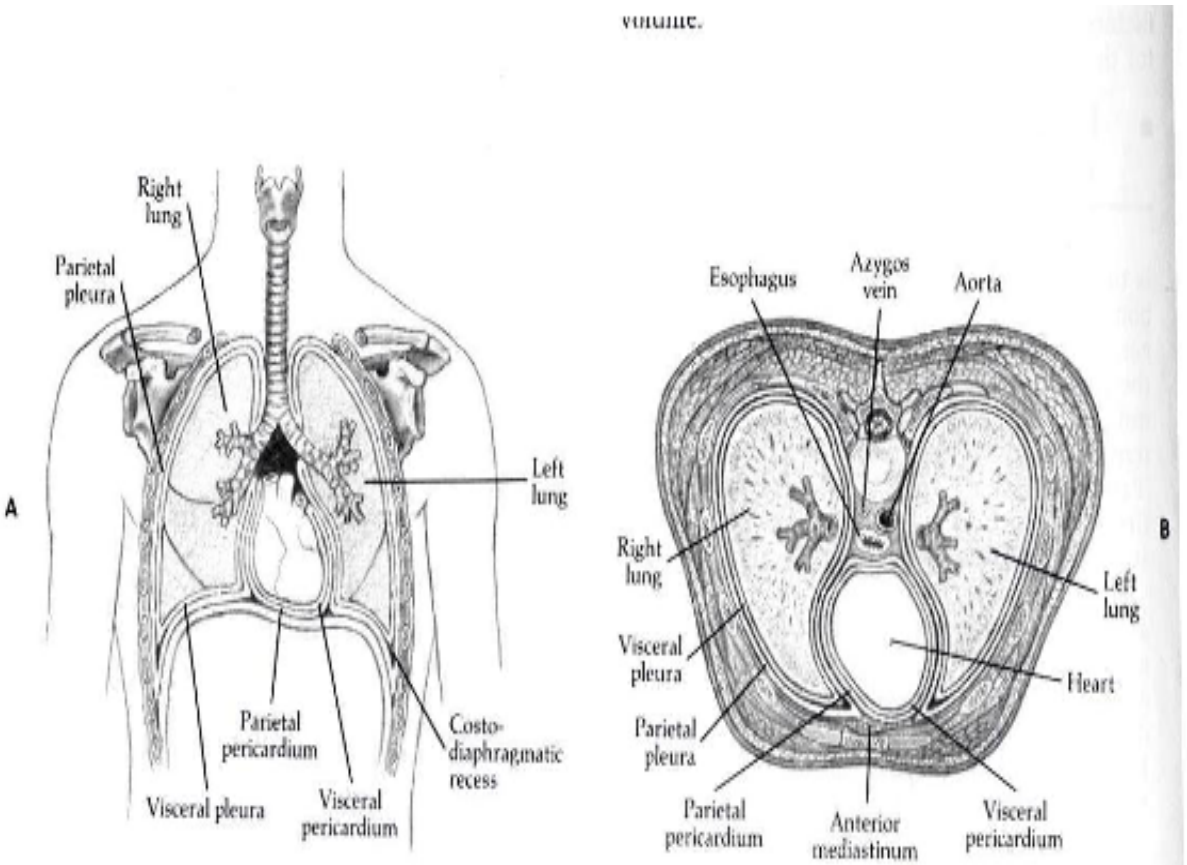


Fig. 6-1 Chest cavity and related structures. **A**, Anterior view. **B**, Cross section.
Reproduced with permission from Thompson JM and others: Mosby's manual of clinical nursing, ed 2, St Louis, 1989, The CV Mosby Co.

- Diaphragm movement can be restricted by abdominal contents or gastric distention. Elevating head of bed 30° or position of comfort may aid respiratory efforts. Insertion of gastric tube for decompression may be required to aspirate air or fluids. (Note: Gastric tube always required with mechanical ventilation and following extended periods of manual ventilation.)
  Normally, diaphragm is dome shaped to aid in contraction. However, when it becomes flattened, due to lung hyperinflation (common with acute asthma and bronchiolitis), contraction less forceful and ventilation less efficient.

3. Airways

Pediatric airways have many differences from those of adult.

3 Main Areas:
1. Supraglottic – nose, naso-oropharynx and epiglottis
2. Glottic – vocal cords, subglottic area and upper trachea
3. Intrathoracic – thoracic trachea, mainstem bronchi and lungs

Supraglottic Area

- Ciliated mucous epithelium in nose filter, warm and humidify air. Infants up to 5 – 6 months of age are primarily nose breathers (due to size and angle of epiglottis) so any obstruction of nares (secretions, edema, blood, chonal atresia) results in respiratory distress.
- Nasopharynx has more lymphoid tissue and large adenoids which can also cause obstruction of airway.
- Tongue of small child is large in relation to mouth and jaw and can obstruct airway in obtunded chilled if their head is too flexed. Placing head in "sniffing" position with small roll under shoulders helps maintain an open airway. (A jaw thrust maneuver should be used if C-spine injury suspected.)

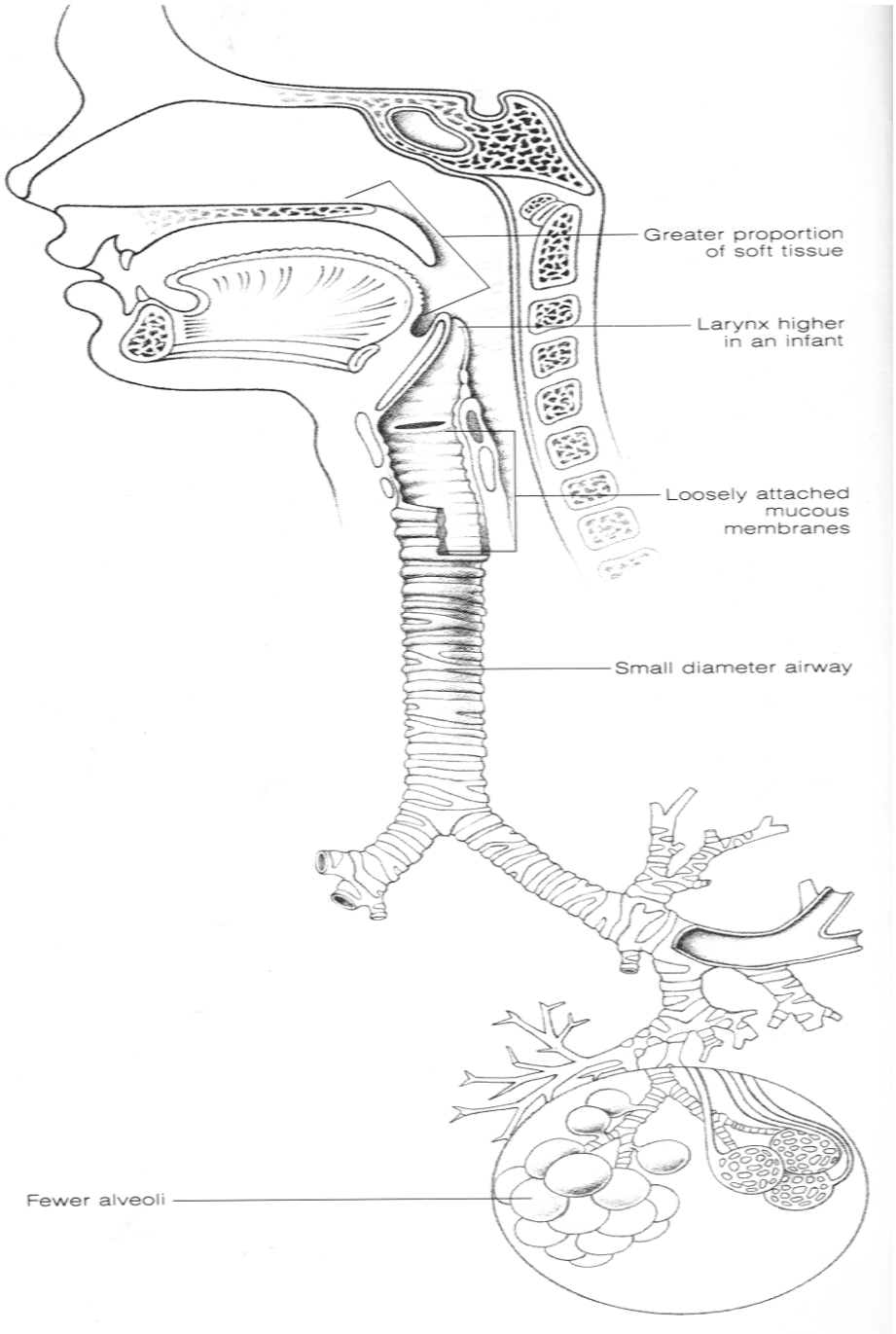
Glottis

- Infants epiglottis is long and floppy, attached at a more acute angle and more posterior making it more difficult to visualize airway structures for tracheal intubation. It is also susceptible to edema with trauma and infection (epiglottitis) which can result in complete airway obstruction.
- The larynx (funnel-shaped structure connecting pharynx and trachea) is more cephalad (towards the head) in child, resulting in a shorter, higher structure (at cervical vertebrate 2 -3 in child and at cervical vertebrate 4 – 5 in adult) putting them at increased risk for aspiration and making intubation more difficult.
- The cricoid cartilage ring is smallest portion of child's airway and the only part of trachea entirely enclosed with cartilage. This ring determines size of endotracheal tube that can be inserted and provides seal around tube in infants and small children. Any edema in this area can produce airway obstruction, increased airway resistance and work of breathing.

Intrathoracic

- Trachea – length increases from 4 -5 cm in infant to 7 cm in adolescent.
- Thin walled cartilage tube of 16 – 20 rings which partially encircle trachea. Posterior trachea wall is smooth muscle. Because of its small diameter, even minimal obstruction results in a dramatic increase in airway resistance and increased work of breathing (i.e. 1 mm of swelling in a 4 mm trachea results in a 75% decrease in open area and 16 times increase in resistance).
- Tracheobronchial Tree – made of smooth muscle which increase until 1 year of age. At 4 – 5 months of age, enough smooth muscle to cause bronchospasm in response to irritant.
- Terminal bronchioles – continue to branch until 1 year.
- Alveoli – alveoli increase in number and size until child about 8 years to increase surface area for gas exchange.

- Lung contains little collagen or elastin in newborn infant, making premature lung at risk for rupture (pneumothorax).
- Collateral ventilation via Pores of Kohn (small holes allowing gas movement between alveoli) does not develop until 2 – 3 years of age. Canals of Lambert (allow bronchio alveolar communication) develop at 6 years of age.
- Absence of this collateral ventilation makes infants and young children more prone to patchy atelectasis.



4. Pulmonary Circulation

Both oxygenated and deoxygenated blood is pumped to lungs. Left ventricle provides oxygenated blood to lungs via 3 bronchial arteries to bronchi, bronchioles, lymph nodes and visceral pleura for growth and cell nutrition. Right ventricle pumps all of its deoxygenated blood to lungs via pulmonary artery. The pulmonary artery then divides into smaller right and left branches that follow airways to alveoli for gas exchange.

Pulmonary artery pressure (PAP) is higher in newly born until reactive muscle layers in the pulmonary arterial beds start to thin in response to more oxygen. This happens in first 6 – 8 weeks of life. However, infants with ongoing hypoxia (premature babies or infants with congenital heart conditions), the muscle layer of vessels may not thin resulting in pulmonary hypertension (PHN) and pulmonary vascular disease (PVD). Even in normal infants (under 6 – 8 weeks old), hypoxia, acidosis, hypothermia, alveolar hyperinflation and stress can trigger vasoconstriction to lungs and decrease pulmonary blood flow.

Lymphatic network is present in pleura, and around pulmonary arteries and veins.

5. Control of Respiration

Respiratory rate and depth are under neural and chemical control to maintain oxygen, carbon dioxide and pH at levels for optimal cellular functions.

Central Respiratory Centers – in pons and medulla responsible for rhythm of respiration.

Peripheral Neural Reflexes – mechano receptors (stretch receptor and C - fibers) in trachea and lungs transmit impulses to brain stem via vagus nerve altering respiratory rate (up or down) and increasing volume of breath. Also stimulates release of substances like histamine and prostaglandin.

Chemical Control – chemosensitive areas in brain and peripheral chemo receptors in carotid body and aortic arch react to changes in pH, carbon dioxide and oxygen as well as circulatory changes to regulate respiration.

A pediatric patient has higher oxygen demand per kg body weight due to higher metabolic needs. O_2 consumption in pediatric patient 6 – 8 ml/kg/min compared to 3 – 4 ml/kg/min in adult. Consequently, apnea, hypoxia and inadequate ventilation develop more rapidly.

6. Oxygenation & Ventilation

O_2 & CO_2 diffuse across 7-layer alveolar pulmonary capillary membrane in direct proportion to surface area, artial pressures of gases and gas solubility (CO_2 20 times more diffusible than O_2)

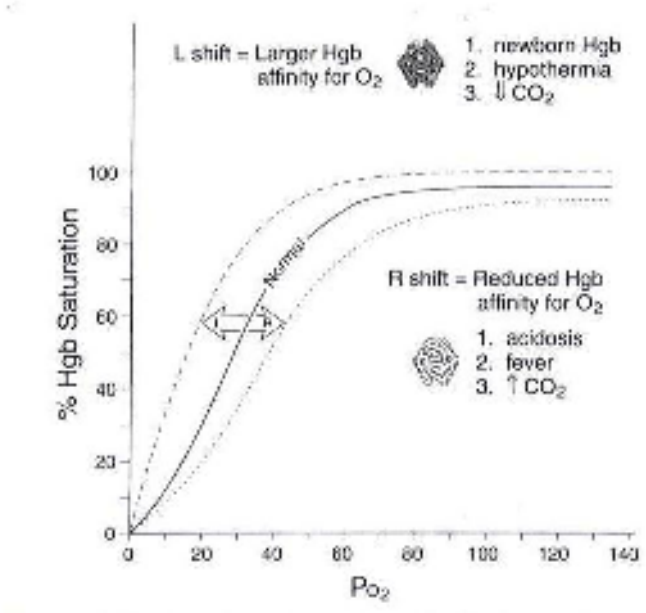
6.1 Oxygen Transport

O2 carried bound to Hemoglobin (97%) and dissolved in plasma (3%)

- SpO_2 measures O_2 bound to Hemoglobin
- Blood gases measure O_2 in plasma

6.1.2 The Oxygenation Dissociation Curve illustrates the affinity of O_2 to Hemoglobin and the relationship between SpO_2 and O_2 (PaO_2) measured with blood gas.

- On the upper or flat portion of curve (PaO_2 > 80 mmHg) variances in O_2 tension (or PaO_2) produce minimal changes in O_2 saturation/content.
- Within the steep portion of curve (PaO_2 < 60 mmHg) a small variance in O_2 tension (paO_2)produces a dramatic drop in O_2 saturation/content.
- This curve can be shifted to Right (reduced Hemoglobin affinity to O_2) or shifted Left (greater Hemoglobin affinity for O_2) by pH, CO_2 levels, temperature and fetal hemoglobin levels. (See Physiology or Nursing Texts for more information)



While clinical measures of oxygenation (SpO_2 and arterial/capillary blood gases) show O_2 diffusion within the lungs, they do not necessarily reflect O_2 delivery to tissues, effective O_2 use by tissues, or the work of breathing (ventilation).

O_2 delivery to tissues influenced by cardiac output (ie. Heart rate, volume of blood), the amount of Hemoglobin, tone in small arterioles that can vasoconstrict or vasodilate and characteristics of capillary wall allowing O_2 diffusion.

Oxygen consumption is amount of oxygen used by tissues - is increased in stress states (pain, fever, activity) and decreased in sleep, relaxation, anesthesia/sedation and hypothermic states.
Under optimal conditions, O_2 delivery matches O_2 needs. However, if O_2 needs exceed delivery, hypoxia will result.

6.2 Ventilation

Ventilation is the process of gases moving in and out of lungs (inspiration and expiration) in response to pressure gradients created by:

8. movement of diaphragm and other respiratory muscles that expand thoracic cavity creating a negative pressure that draws (pulls) gases in through upper airways/trachea.
9. Positive pressure ventilation (manual ventilation with bag – valve mask or mechanical ventilator) that forces (pushes) gases into thoracic cavity to expand lungs.

How easily gases are able to flow into lungs depends upon:

6.2.1 Compliance or elasticity of lungs and chest wall or how much pressure is needed to produce a volume change within lungs. Compliance changes with:
- age – newborn lungs are relatively tight
- disease states – disease decreasing amount of surfactant such as ARDS, decrease compliance (lungs more stiff).
- Chest wall/thoracic deformilies like scoliosis, obesity and muscular dystrophies make it harder to move chest wall.

6.2.2 Airway Resistance – is the pressure needed to move gases into or out of lungs at specific flow rate or time interval:
- Small airway diameters in children contribute up to 50% of resistance (compared to 20% in an adult)
- Normally, airways are pulled open during inspiration by bronchial smooth muscle and become slightly smaller during the elastic recoil of expiration.

- Bronchial muscle is regulated by autonomic nervous system with sympathetic (flight or flight) stimulation causing bronchial dilation and parasympathetic stimulation causing constriction.
- Disease states, such as asthma and bronchiolitis can cause bronchial constriction resulting in increased work of breathing air, trapping and diminished tidal volumes. Chemical mediators such as histamine release in anaphylaxis, also cause bronchial constriction.
- Medications such as Salvulamol (Ventalin) via sympathetic receptors to help bronchodilate, while medication, like Atrovent, help block parasympathetic induced bronchial constriction.

Note:

How quickly and easily gases are able to flow in and out of lungs depends upon compliance (elasticity) of lungs and chest and resistance produced by the size of the patient's own and artificial airways. It is therefore, extremely important to keep pediatric natural and artificial airways free of secretions. Remember that Endotracheal and tracheostomy tubes are always slightly smaller than normal airway. This, as well as edema and broncho spasm, increase the work of breathing required to move air through narrowed airways. Addition of airway extenders on ETT's or tacheostomy tubes or some forms of oxygen delivery devices (ie. Easy Breather on trach tube) can

also increase resistance and work of breathing as extend the length and resistance of external airway.

7. Volume of Breath

The usual volume of each breath is 6 – 7 mls/kg although larger volume breaths can be generated when bodies gas exchange requirement increase.

Minute of Ventilation – the amount of air moving in and out of lungs in 1 minute and is the product of respiratory rate and volume.

- Obviously increasing rate and volume increases minute ventilation.
- Decreasing rate and volume results in decreased minute ventilation, a critical situation resulting in hypoxia.
- However, slower, large volume breaths may still produce adequate minute ventilation (ie. When child asleep).
- Small volume breaths may be tolerated, provided the compensatory increase in respiratory rate can be sustained (ie asthmatic with air trapping)

Dead Space – not all of the volume of gases entering the respiratory system participates in gas exchange.

- Gases in nose, pharynx, trachea and bronchials (about 2 mls/kg) remain unchanged and are referred to as Anatomical Deadspace.
- Deadspace may be increased with use of artificial airways (ETT and tracheostomy tubes) especially if extension devices are large in relation to patients tidal volumes. These devices can also trap exhaled CO_2 and result in rebreathing and increased blood CO_2 levels.

8. Ventilation/Perfusion Relationships

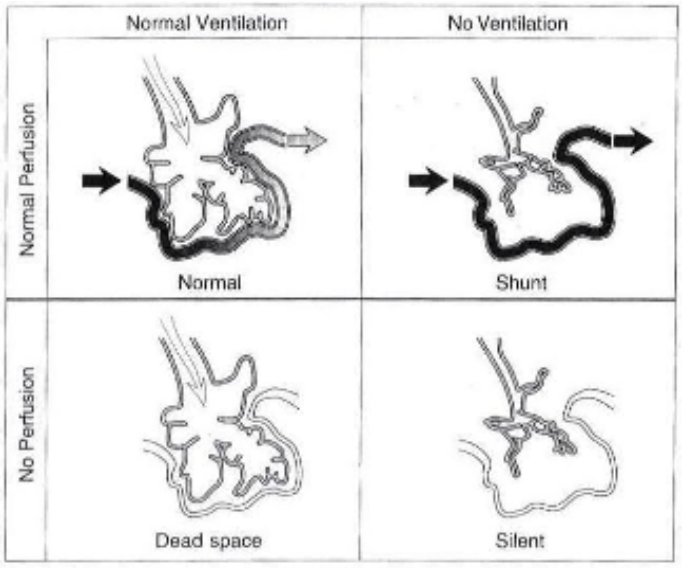
- Optimal gas exchange occurs when ventilation (air) and perfusion (pulmonary blood flow) are equally matched. However, even under ideal circumstances this ventilation – perfusion ratio (v/Q) is not 1:1 as gravity draws blood downward while gases tend to rise upward.
- Patient position whether upright, supine or prone, changes this relationship. In healthy children (and adults) the body easily compensates and adjusts for the difference and position changes. However, in the abnormal lung, problems may arise.

    a) Intrapulmonary Shunt – venous (deoxygenated) blood travels from Right side of heart through lungs and back to Left side of heart without ever coming in contact with ventilated alveoli so no gas exchange occurs. Examples: ateleclasis, pneumonia, pneumothorax, apnea.

    b) Physiological Dead Space – alveoli ventilated but not perfused therefore, no gas exchange.

Examples: Pulmonary emboli, pulmonary vasoconstgriciton associated with hypoxia acidosis, hypothermia in young infant, cardiopulmonary arrest with ineffective compressions.

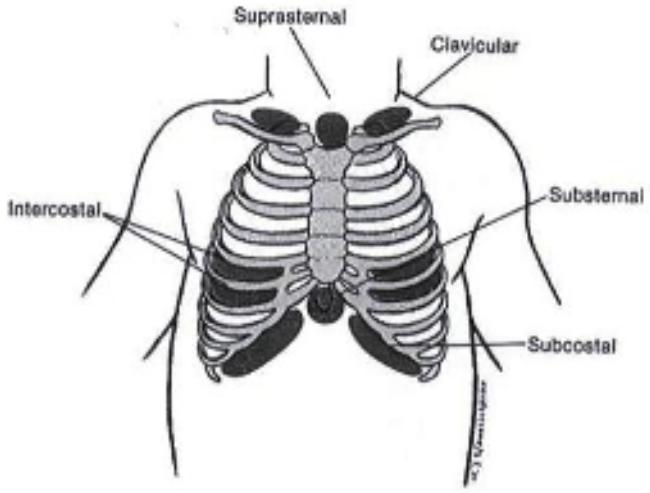
c) Silent Unit – no alveolar ventilation or perfusion Examples: cardio respiratory arrest without interventions.



Appendix C:

Assessment of Pediatric Respiratory System

A. Inspection
- Chest shape and anterior posterior diameter compared to lateral diameter
  - Barrel shape (Round) – normal in infant. Indicates chronic respiratory problems in child >3 yrs.
  - Pectus Excavatum (Funnel Chest) – depression of lower portion of sternum.
  - Pectus Carinatum (Pigeon Chest) – anterior displacement of sternum
  - Thoracic Kyphosoliosis – spinal curvature displaces thorax
- Slope of ribs – infant ribs more horizontal
- Abnormal retractions

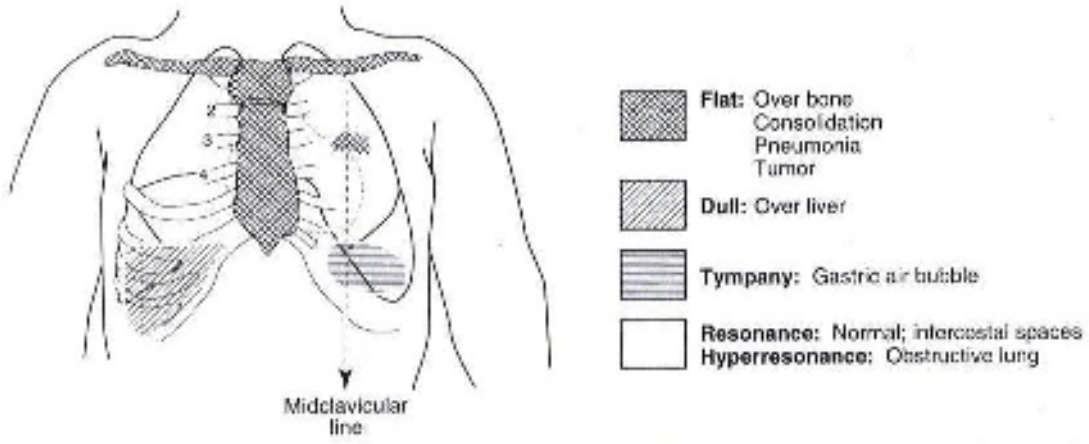


- Movement of chest
  - Symmetrical
  - Lag or impairment of movement
  - Synchrony with abdomen - use of accessory muscles
- Rate & Rhythm of Breathing
  - Normal rates
- Tachynea is non-specific sign
  - Concern with RR over 40/min
  - Ominous if RR over 60/min

B. Palpation
- Areas of tenderness
- Assess respiratory excursion – symmetrical?
- Assess abnormalities
  - Subcutaneous emphysema (crepitus) – course, crackly feeling (and sound) of air in tissues
    - “rice krispies” – indicated air leak into tissues

- Tactile tremitus
  - Vibrations diminished with poor air entry, consolidation
  - Vibrations increased with copious secretions or pleural friction rub
- Position of trachea – eviation may indicate fluid or air collection or collapsed lung (ie tension pneumonthorax)

C. Percussion
- Normal lungs should have resonance
- Dull/flat indicates solid organ (liver) or atelectasis/consolidation
- Hyper resonance/tympany indicated air trapping (gastric bubble or pneumothorax)



D. Auscultation
- Compare symmetrical areas of lung, listening anteriorly, laterally and posteriorly (if possible)
- Note quality, intensity and duration of breath sounds in respiratory cycle.
- Adventitious/abnormal sounds and timing in respiratory cycle,

Breath Sounds
- Normal Sounds
  - Bronchial (I<E) – slightly longer expiratory phase. High pitch, loud, blowing. Normally over large airways (trachea, bronchi)
  - Broncho-vesicular (I=E) – high pitched tubular sounds. Normal in infants due to transmission through small chest.
  - Vesicular (I>E) – longer inspiration phase. Low pitch and soft. Heard normally over peripheral lung fields.
- Adventitious Sounds
  - Crackle – discrete, non-continuous sound. Primarily on expiration.
  - Fine High Pitched Crackling (Creps) – hair rolling between fingers. Usually heard end of expiration indicating wet lungs (pulmonary edema).
  - Medium Crackles – mid to early inspiration. Indicates secretions in bronchioles.

- Course Crackles – course, bubbling, usually in larger airways. Clear with cough.
- Friction Rub – grating, low pitched on inspiration and expiration by inflamed pleural surfaces.
- Wheeze – indicate partial obstruction of air flow in narrowed passages (edema, bronchospasm). Differences in pitch related to velocity of air flow (high pitched, musical or low pitched, sonorous). May be associated with prolonged expiratory time.
- Diminished or absent breath sounds – focal or global indicating poor air flow.
  - Ominous sign – noisy chest is good chest!
- Stridor – inspiratory sound produced by narrowing in upper airway structures. Crowning or raspy sound. Often accompanied by hoarse voice/cry or diminished voice/cry.

APPENDIX B: Developmental Care Practices

Suctioning can be a frightening and anxiety producing procedure for all children. Developmental Care Principles to incorporate during this procedure include:

- Timing procedure to infant's sleep/wake cycle whenever possible. For older children, always tell them what you will be doing before start of procedure, and ways they can help you during procedure. For example: tell them that suctioning will make them cough but that you will let them rest following.
- Provision of containment and support of the infant during the procedure by using positioning, flexion and swaddling. For older children, a second health care provider should be present to help ensure patient does not grab at endotracheal tube or move head excessively.
- Tailoring the pace of the procedure to respond to the infant's cues and allowing the infant to reorganize to a calm state.
- Provision of a 20 to 30 minutes rest post-procedure to recover before the next activity, for example: feeding is especially important in infants. Whenever possible, suctioning should be done before feeds to minimize risk of vomiting.
- Chest physiotherapy and/or positional changes should be done prior to suctioning if possible, as these therapies may loosen secretions.

APPENDIX C: Measured Suction Depth

All routine suction passes should be to pre-measured depth to minimize risk of trauma to delicate tracheal tissues. Repeated suctioning past end of endotracheal or tracheostomy tube can result in bronchial perforation, hemorrhage, histological changes and airway inflammation and tracheal stenosis. Suction catheter should not pass beyond distal end of endotracheal or tracheostomy tube on a regular basis. **Suction Catheters should never be inserted until resistance felt, as this causes trauma to carina.**

Endotracheal Tube:

- Suction depth can be measured by noting cm markings on endotracheal tube visible at teeth or gums, then adding length of endotracheal tube and adapter beyond this. This measurement should not need adjustment with the tube depth adjustments as entire tube moves up or down.
- For In-line suction catheters size 6, 8, 10 French – measure as above or add 5 cm to last visible cm marking on tube for approximate suction depth.

Tracheostomy Tube: Use length of tracheostomy tube indicated on box plus measured distance of Tracheostomy above stoma (add length of adapter if used). Length of obturator may also be used to calculate suction depth but will be slightly longer than tracheostomy tube.

- Suction Depth measurement should be posted at bedside of all pediatric patients and documented on patient care plan. Suction catheter should only be inserted to this depth on regular basis. Utilize cm markings on catheter, bedside measuring tape or color-coded bars on in-line catheter to determine suction depth.

5.0 REVIEW QUESTIONS

NAME: _____ **DATE:** _____

1. State 2 reasons for suctioning an artificial airway.

___ (1)

2 (2)

2. What signs and symptoms indicate that a patient with tracheostomy or endotracheal tube requires suctioning?

(1)

___ (2)

4 (3)

(4)

3. Answer True (T) or False (F) to the following questions:

(1)	Tracheostomy/ ETT suctioning is painless, causing no anxiety to the patient.	❑ True	❑ False
(2)	Suctioning is effective only for secretions in the upper airways.	❑ True	❑ False
(3)	The patient should be positioned at 30° upright if possible during suctioning.	❑ True	❑ False
(4)	Routine suctioning should be to pre-measured depth to prevent trauma to delicate tissues.	❑ True	❑ False
(5)	Suctioning should be performed whenever an expiratory wheeze is heard	❑ True	❑ False

___ 5

4. List three signs that suctioning has been effective.

(1)

___ (2)

3 (3)

5. Jimmy, a 6 month old baby has a 4.5 Neonatal Tracheostomy in place. The length of the tracheostomy tube as indicated on the box 36 mm. About 4 cm of the tracheostomy is external to patient. With an extension (adapter) device on tracheostomy tube. Routine suction depth is _____cm.

____
1

6. When obtaining a tracheal secretion for culture and sensitivity (C&S) which of the following best describes the procedure:

a) utilized modified sterile technique and sterile H_2O for instillation

____ b) utilized sterile technique and "open" suction method

1 c) utilize universal precautions and clean gloves

d) utilize clean gloves and hyperventilation techniques

7. Which of the following does <u>not</u> describe suctioning the pediatric airway:

a) Suction pressure should be set as low as possible but able to remove secretions

____ b) Instillation of 0.9% saline may be considered when secretions thick and

1 tenacious

b) Extra oxygen should be given prior to and during suction if patient desaturating

c) The suction catheter should be advanced until resistance felt, withdrawn 1cm then suction applied.

8. Which of the following patient conditions warrant extra caution with tracheal suctioning:

a) Those with traumatic brain injury

____ b) Those with low platelet count

1 c) Those receiving bronchodilators frequently

d) All of the above

9. Suction policy advocates catheter size no more than 2/3 of diameter of airway. What circumstance may warrant a larger catheter and why?

____
2

____
20

6.0 Definitions/Abbreviations

PEEP – Positive End Expiratory Pressure. Pressure exerted by mechanical ventilation at end of expiration to prevent alveoli from complete collapse and aide in gas exchange.

SpO_2 – oxygen saturation

$ETCO_2$ – end-tidal carbon dioxide – spectrometry device attaches to end of endotracheal tube or tracheostomy tube. Able to measure CO_2 of exhaled gases. Normally 35 – 45 mmHg.

ETT – endotracheal tube